APPENDIX B

REVIEW OF DELTA CROP COEFFICIENTS

State of California
The Resources Agency
Department of Water Resources
Central District
San Joaquin District

REVIEW OF DELTA CROP COEFFICIENTS

by

Norman MacGillivray and George Sato

Retired Annuitants

Office Report

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REVIEW OF DELTA CROP COEFFICIENTS

The purpose of this paper is to provide a brief discussion of the procedures generally followed in confirming and/or revising crop coefficients presented by Tariq Kadir for our review at the October 11, 1995 meeting.

Present at that meeting were Tariq Kadir, Maury Roos, Norman MacGillivray, Mini Mahadevan, Hari Rajbhandari, and George Sato. Tariq Kadir presented the latest calculation of monthly Delta ETo values for each year 1922 to 1992. These were based on the previously established average annual ETo of 46.1 inches. The consensus among the participants was that the new variable ETo values appear appropriate and reasonable.

The next phase of the discussion concerned specific crop coefficients to be adopted and calculate the respective crop ET values. The meeting concluded with a decision to have Norman MacGillivray and George Sato (retired annuitants) review reported values for the Delta and recommend revision as necessary.

It should be pointed out that the above activity is not a new endeavor but an extension of the study presented by Tariq Kadir on March 24, 1994. Since that time, Norman MacGillivray and George Sato jointly published an office report, Evaluation of ET-Grass (ETo) In the Delta, dated October 1994. That report recommended 46.1 inches as an average annual ETo value representing the entire area defined by DWR as the Delta Service Area.

MacGillivray and Sato initiated the specific crop coefficient study with a review of previously reported ET values. These values provide a basis for extrapolating crop coefficients that appropriately represent existing and past cultural practices in the Delta. During the review process, it became apparent that ETo during the non-growing season is influenced not only by soil moisture and climatic conditions but also by post harvest cultural practices. Consequently, George Sato made a field trip to observe typical Delta field conditions on November 16, 1995. The area observed was limited to the North Delta area. Sato and MacGillivray traveled to the remaining South Delta area on November 30, 1995. Photographs and field observations are contained in Appendix B.

Review of the reference materials (Appendix A) was begun by comparing the values developed by Maurice Roos in the late 1970s and, more recently, in 1995 by the Hydrology Development Unit of the Division of Planning for use in the Delta Consumptive Use Model. Those values primarily used crop Kc's contained in Bulletin 113-4 (memo from Tariq Kadir to George Sato, April 28, 1992).

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When MacGillivray compared those values to the field plot measurements tabulated in DWR Bulletin 113-3 (Table 5), differences, usually slight, were noted. He then tried to determine the sources of Kc's listed in Table J-3 of Bulletin 113-4. He found no references cited for the source of data in that table. However, he deduced the source of values for Table J-3. His comments are noted **verbatim** in the following:

1. Table 5 of Bulletin 113-3 lists monthly Kp's (coefficients relating crop ET to evaporation from class "A" pans) developed from DWR field measurements.

2. These Kp's were basis of crop ET for the Delta, presented in a memo report, Estimation of Monthly Crop ET for Central Valley Hydrology Study, November 3, 1976.

3. In 1978, DWR cooperated with UC Davis to work up "Drought Tips" for the Interagency Drought Task Group. Elias Fereres was the principal UC person, but Bill Pruitt reviewed and advised. I participated for DWR, and DWR hired John Shannon, who was retired, as a consultant who worked full time on this. We started with monthly Kp's from Table 5, Bulletin 113-3. Fereres had a computer program to fit smoothed curves to the monthly points and then interpolate weekly Kp's for each crop. Kp's were divided by 0.8 to convert to Kc's. Crop ET's were then calculated using evaporation where it was available (with Kp's); and where evaporation was not reliably known, the base was ET of grass from Bill Pruitt's ETo maps of the State with Kc's. The "Drought Tips" were leaflets by area and crop groupings and were distributed to farm advisors, SCS, irrigation districts, etc. to help farmers make the best use of the limited supplies of available irrigation water.

   Because the calculated weekly Kp's and Kc's were smoothed curves and were rounded off, they often differed slightly from original measured data. Also, I think (but I'm not real sure) that we used 0.8 to convert all Kp's to Kc's. The actual measured DWR data shows Kp's for grass vary from about 0.75 to 0.78.

4. Now I think that about 1990± DWR in Statewide Planning gave a listing of weekly Kc's to the fellows working on CIMIS. (I wasn't involved in this) and I think the source was the "Drought Tip" tabulations but I need to check this out. At the time Glenn Sawyer told me that was the case.

5. I believe that the Kc's listed in Table J-3 of Bulletin 113-4 are from the CIMIS tabulations, but again this needs to be checked out.

6. The calculated ET's for the Delta from the Central Valley Hydrology Study of 1976 were calculated to account for early, mid, and late season planting and harvest. And an average, by month, for various annual crops or crop groupings (such as field) was developed. This was done to spread the ET over the entire growing season and not have a very high peak for one month and low ET for early and late months.

   Anyhow, I'm not sure if Price did that after changing to numbers agreed to between DWR and USBR in 1979. This needs to be looked into.

7. Any changes in total water used in the Delta attributable to differences in Kc's are probably small, but I think it is important to document exactly how the Kc's were developed.

8. The important thing is not so much the slight differences but the need to relate the Kc's to the measured ET data and, thus, substantiate those Kc's.

9. There is one other important piece in all of this. That is that in 1979, George Sato, Rich Cocke, Price Schreiner, and I from DWR met with John Montieth and Gordon Lyford for WPRS[1] on crop ET's in the Delta. We adjusted the values calculated by DWR and USBR (Table A) and agreed on a set of average year monthly ET's for a number of Delta crops as shown in Table B.

   I believe Price maybe changed inputs to the Delta Consumptive Use computer program to account for those changes in monthly ET. These agreed upon ET's were by crop and, I think, not by crop grouping.

In summary, Table B shows the range of growing season crop ET calculated by DWR and by USBR and the agreed to value. The crop ET based on Kc's used by the Consumptive Use Model compare exactly with the ET values derived for the Joint DWR and WPRS Delta Channel Depletion Analysis, April 1, 1981. The ET values are from the tabulation, compiled by Rich Cocke, dated November 29, 1979. The tabulated values are for an average year and are those agreed to in 1979 by Price Schreiner (DWR), Gordon Lyford (USBR), Rich Cocke (DWR), George Sato (DWR), and Norman MacGillivray (DWR). John Montieth's (USBR) name is not listed on the tabulation but is listed as a participant on the accompanying note, dated 12/10/79. The details of this effort are described in a report, Joint DWR and WPRS Delta Channel Depletion Analysis, April 1981(revised 4/24/81). This report was prepared by Gordon Lyford (USBR), George Sato and Price Schreiner (DWR).

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[1]For a short period of time, USBR operated under the title Water and Power Resources Service (WPRS). Throughout this document we will use USBR.

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TABLE A

Tabulation of Delta ET as estimated by DWR and USBR (1979)

ET in inches

Crop/Person	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
Pasture													
MacGillivray	0.7	1.5	2.7	4.1	5.5	6.4	7.6	6.6	4.8	2.8	1.4	0.6	44.7
Lyford	1.0	1.0	2.9	4.2	5.8	6.6	7.4	6.6	5.0	3.0	1.0	1.0	45.5
Alfalfa													
M	0.7	1.5	2.4	3.7	5.0	6.0	7.4	6.7	4.8	2.9	1.4	0.6	43.1
L	1.0	1.0	2.9	4.2	5.8	6.6	7.4	6.6	5.0	3.0	1.0	1.0	45.5
Past/Alf													
M&L	0.7	1.5	2.7	4.1	5.5	6.4	7.6	6.6	4.8	2.8	1.4	0.6	44.7
Orchard													
M	0.7	1.5	2.1	2.9	4.6	5.7	7.3	6.3	4.2	2.3	1.4	0.6	39.6
L	1.0	1.0	1.1	2.2	5.2	6.1	6.8	6.0	4.6	2.8	1.0	1.0	38.8
M&L	0.7	1.5	1.7	2.7	4.9	5.9	7.0	6.1	4.4	2.5	1.2	0.6	39.2
Tom/machine													
M	0.7	1.5	2.1	1.5	3.0	6.1	8.1	5.2	2.3	1.0	1.4	0.6	33.5
L	1.0	1.0	1.0	1.0	3.4	6.6	8.5	5.8	1.0	1.0	1.0	1.0	32.3
M&L	0.7	1.5	1.6	1.3	3.2	6.4	8.3	5.5	1.7	1.0	1.1	0.6	32.9
Sugar Beet													
M	0.7	1.5	2.1	1.5	4.2	7.0	8.2	6.6	4.3	1.7	1.4	0.6	39.8
L	1.0	1.0	1.0	1.0	2.2	5.0	7.6	6.7	5.2	3.1	1.0	1.0	35.8
M&L	0.7	1.5	1.7	1.3	3.2	6.0	7.9	6.6	4.8	2.3	1.1	0.6	37.7
Corn/Sorghum													
M	0.7	1.5	2.1	1.5	2.5	5.4	7.0	4.8	2.1	1.1	1.4	0.6	30.7
L	1.0	1.0	1.0	1.0	1.8	5.9	8.3	6.1	1.9	1.0	1.0	1.0	31.0
M&L	0.7	1.5	1.7	1.6	2.6	5.5	7.3	4.9	2.2	1.1	1.1	0.6	30.8
Dry Beans													
M	0.7	1.5	2.1	1.5	1.9	5.3	6.1	2.8	1.2	1.0	1.4	0.6	26.1
L	1.0	1.0	1.0	1.0	1.0	1.4	4.8	6.8	2.7	1.0	1.0	1.0	23.7
M&L	0.7	1.5	1.7	1.5	1.9	5.3	5.8	2.8	1.2	1.0	1.1	0.6	25.1
Safflower													
M	0.7	1.5	2.1	1.9	5.5	8.1	7.6	4.5	1.8	1.0	1.4	0.6	36.7
L	1.0	1.0	0.7	2.4	5.6	7.8	6.0	1.2	0.8	1.0	1.0	1.0	29.5
M&L	0.7	1.5	1.7	2.0	5.5	7.9	6.7	2.7	1.2	1.0	1.1	0.6	32.6
Asparagus													
M	0.7	1.5	2.1	1.5	1.0	3.2	7.6	6.6	4.6	2.1	1.4	0.6	32.9
L	1.0	1.0	1.0	1.0	1.1	2.9	6.8	7.6	5.8	2.3	1.0	1.0	32.5
M&L	0.7	1.5	1.7	1.5	1.1	3.2	7.6	6.8	4.8	2.1	1.1	0.6	32.7

Table A *cont.*													
Crop/Person	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
Grain													
M	0.7	1.5	3.3	4.3	3.6	1.6	1.0	1.0	1.0	1.0	1.4	0.6	21.0
L	0.2	0.8	2.6	4.9	6.4	2.8	1.0	1.0	1.0	1.0	1.4	0.6	23.7
M&L	0.7	1.5	2.7	4.6	5.0	2.2	1.0	1.0	1.0	1.0	1.1	0.6	22.4
Vineyard													
M	0.7	1.5	2.1	1.5	3.2	4.9	6.4	5.5	3.3	1.1	1.4	0.6	32.2
L	1.0	1.0	1.0	1.2	4.0	5.3	6.0	5.3	4.1	1.0	1.0	1.0	31.9
M&L	0.7	1.5	1.7	1.5	3.6	4.9	6.4	5.3	3.6	1.1	1.1	0.6	32.0
Water Surface													
M	1.0	2.0	3.5	5.3	7.1	8.2	9.7	8.4	6.0	3.8	1.9	0.9	57.8
L	1.0	1.8	3.4	4.9	6.6	7.6	8.5	7.6	5.8	3.5	1.6	1.0	53.3
M&L	1.0	1.9	3.4	5.1	6.9	7.9	9.0	8.0	5.9	3.7	1.7	0.9	55.4

For this effort, ET values for 13 crop categories, including water surface, were evaluated. Gordon Lyford estimated crop ET using the Jensen-Haise equation, with solar radiation from UC Davis and air temperatures measured at Brannan Island in the Delta. He used average data for the ten-year period from 1968 to 1977.

DWR estimates were from Table B-8 of a memo, Estimation of Monthly Crop ET for Central Valley Hydrology Study, November 3, 1973. Those estimates were based upon Kp's listed in Table 5, DWR Bulletin 113-3, April 1975.

Table B, on the following page, shows a comparison of the total growing season ET estimates by DWR, USBR, and the agreed upon compromise values. Note that except for safflower, sugar beets and water surface the estimates are reasonably close.

TABLE B

Comparison of Total Growing Season[1] ET
for Delta Crops Estimated by DWR and USBR

CROP	DWR	USBR	AGREED ET
	<----------	ET in inches	---------->
Pasture	44.7	45.5	
Alfalfa	43.1	45.5	
Pasture/Alfalfa[2]			44.7
Orchard	35.4	34.8	35.2
Tomato (machine)	29.3	28.3	29.0
Sugar Beet[3]	35.6	31.8	33.8
Corn-Sorghum	26.5	27.0	26.9
Dry Beans	21.9	19.7	21.2
Safflower	32.5	25.5	28.7
Asparagus	28.7	28.5	28.8
Grain	17.0	19.7	18.4
Vineyard	25.9	26.9	26.4
Water Surface/Riparian	57.8	53.0	55.4

One thing that needs to be looked into is that USBR may have developed their crop coefficients for the Jensen-Haise equation from data contained in DWR Bulletin 113-3. MacGillivray expressed the need to talk to Joe Lord about this as Lord was a key participant in the USBR's development of the Jensen-Haise equation for their Irrigation Management Service.

The close agreement between the crop ET's, independently estimated by DWR and USBR in the effort mentioned above, steered MacGillivray to follow up on this.

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[1]Growing Season assumed to be Mar-Oct, except: Grain, Nov-Jun; and Pasture, Alfalfa, and Water Surface, Jan-Dec; Vineyard, Apr-Oct.

[2]Pasture assumed to be same as Alfalfa.

[3]Annual crop, plant Spring, harvest late Summer.

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MacGillivray noted that, "It is unusual to have independent estimates of ET agree this well."

MacGillivray's follow up comments are included **verbatim** in the following:

1. The DWR estimates are from Table B-8, memo report Estimation of Monthly Crop ET for Central Valley Hydrology Study, November 3, 1976. That report cites Table 5, DWR Bulletin 113-3 as the basis for those ET estimates. Most crops are included, but some (e.g. evaporation from water surface and ET of riparian vegetation) were from work done in the Delta by D.C. Muckel, USDA-ARS in the late 1950's and reported in his publication Evaporation Investigations in the San Francisco Bay Region, California, Annual Progress Report 1957, USDA-ARS Berkeley, Ca.

2. The USBR estimates were made by Gordon Lyford using the Jensen-Haise equation. He used solar radiation from UC Davis and air temperatures from Brannan Island in the Delta, data was averaged for the ten year period 1968 - 1977. Crop curves, Kc's, were from USBR Irrigation Management Service activity. (See report Joint DWR and WPRS Delta Channel Depletion Analysis by Gordon Lyford, George Sato, and Price Schreiner, April 1, 1981).

3. Because the growing season ET's shown in Table B are in such good agreement, I wondered if they might have the same roots.

4. Today (February 27, 1996), I called Joe Lord to inquire as to the source of USBR's crop curves. Joe was a key person involved in developing the USBR Irrigation Management Service program. I think he was located at USBR's Denver office at the time. I have a recollection of providing him with a copy of DWR Bulletin 113-3.

   Joe said that the crop curves (Kc's) were developed largely by Marvin Jensen USDA-ARS. Joe said Marv had consulted Bill Pruitt, UC Davis, to obtain measured crop ET's and that he (Joe) recalls that the curves developed by Marv were a "mish-mash" of data from Pruitt and that Pruitt had also included much data from DWR Bulletin 113-3.

5. So, if the ET's estimated by USBR and by DWR have the same source, they would be expected to agree.

6. What is important here is that the estimate of alfalfa by USBR does agree with DWR's estimate of alfalfa ET to within 5 or 6 percent. The USBR estimate based upon Jensen-Haise equation is independent of the evaporation pan

based estimate of DWR. Both indicate a lower ET in the Delta than in the surrounding Sacramento/San Joaquin Valley floor.

Other reported Kc and ETo values used in past studies were also reviewed and subjected to a comparative analysis. The analyses assume the assumptions expressed by the following equations:

$$Kp = \frac{ETcrop}{Ep}$$

$$ETcrop = Kp \times Ep$$

$$Kc = \frac{ETcrop}{PET} \qquad PET = ETgrass = ETo$$

$$PET = Ep \times .80 \pm$$

$$\therefore Kc = \frac{ETcrop}{.80 \times Ep}$$

$$\therefore Kc = \frac{Kp}{.80}$$

The results of thes analyses for alfalfa, orchard, vineyard, and field crops are illustrated in detail on the following pages: Tables C through F.

TABLE C

Crop Coefficients (Kc) and ET for ALFALFA
in Sacramento/San Joaquin Delta

$$Kc = \frac{ETalf}{PET} = \frac{ETalf}{ETgrass} = \frac{ETalf}{ETo}$$

					<----------ETalf (inches)---------->			
Month	Kc[1] consump use model	Kc[2] Bulletin 113-4	Kc[3] Bulletin 113-3	Avg[4] ETo	Consump[5] use model	B113-4[6]	B113-3[7]	ETalf[8]
Jan	1.00	1.06	1.00	0.70	0.70	0.70	0.70	0.70
Feb	1.00	1.02	1.00	1.50	1.50	1.50	1.50	1.50
March	0.90	0.99	0.92	3.00	2.70	3.00	2.80	2.70
April	0.91	0.97	0.91	4.50	4.10	4.40	4.10	4.10
May	0.92	0.97	0.91	6.00	5.50	5.80	5.50	5.50
June	0.93	0.97	0.94	6.90	6.40	6.70	6.50	6.40
July	0.97	0.97	0.97	7.80	7.60	7.60	7.60	7.60
Aug	1.03	0.97	1.03	6.40	6.60	6.20	6.60	6.60
Sept	1.04	0.98	1.04	4.60	4.80	4.50	4.80	4.80
Oct	1.04	1.00	1.03	2.70	2.80	2.70	2.80	2.80
Nov	1.00	1.04	1.00	1.40	1.40	1.50	1.40	1.40
Dec	1.00	1.08	1.00	0.60	0.60	0.60	0.60	0.60
TOTAL				46.1	44.70	45.20	44.90	44.70

[1]From M. Roos Consumptive Use Model (ETcrop/ETgrass)

[2]Monthly Kc's estimated from weekly Kc's reported in Table J-3 DWR Bulletin 113-4.

[3]Kc calculated as Kp/PET from Table 5, Bulletin 113-3. PET is given at top of Table 5.

[4]ETo = "New variable Delta ETo" from Handout Table of 10/11/95.

[5]Est ETalf using Avg ET and Kc from Consumptive Use Model.

[6]Est ETalf using Avg ET and Kc from Bulletin 113-4.

[7]Est ETalf using Avg ET and Kc from Bulletin 113-3.

[8]Alfalfa ET for Delta per DWR/USBR agreement 11/29/79.

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Crop Coefficients (Kc) and ET for DECIDUOUS ORCHARD
in Sacramento/San Joaquin Delta

	1[1]	2[2]	3[3]	4[4]	5	6	7[5]	8[6]	9[7]	10[8]	11[9]	12[10]	13[11]	14[12]
	<——————Kc's——————>													
		<————B113-4, Table J-3————>												
		<——Clean Till——>												
	CU	B113-4	B113-3	2/15-	3/1-	4/15-	Cover	Avg. of		Est.	Est.	Est.	Est.	DWR/
Month	model	DOP 1995		11/8	11/8	11/8	1/1-12/31	4,5,6,&7	ETo	ETdo	ETdo	ETdo	ETdo	USBR
Jan	1.00	0.65					1.00		0.70	0.70	0.50	0.70	0.70	0.7
Feb	1.00	0.64		0.28			1.00	0.32	1.50	1.50	1.00	1.50	1.50	1.5
Mar	0.57	0.68	0.59	0.66	0.60		1.04	0.58	3.00	1.70	2.00	1.80	1.70	1.9
Apr	0.60	0.78	0.71	0.79	0.72	0.27	1.11	0.72	4.50	2.70	3.50	3.20	3.20	3.0
May	0.82	0.88	0.83	0.89	0.85	0.65	1.18	0.89	6.00	4.90	5.30	5.00	5.30	5.3
Jun	0.86	0.96	0.90	0.96	0.94	0.79	1.20	0.97	6.90	5.90	6.60	6.20	6.70	6.3
Jul	0.90	1.00	0.96	0.96	0.96	0.88	1.21	1.00	7.80	7.00	7.80	7.50	7.80	7.2
Aug	0.95	1.01	0.96	0.94	0.96	0.95	1.19	1.01	6.40	6.10	6.50	6.10	6.50	5.9
Sep	0.96	0.96	0.91	0.82	0.88	0.96	1.14	0.95	4.60	4.40	4.40	4.20	4.40	4.2
Oct	0.93	0.87	0.80	0.65	0.76	0.98	1.08	0.87	2.70	2.50	2.30	2.20	2.30	2.4
Nov	0.86	0.72				0.46	1.02	0.37	1.40	1.20	1.00	1.20	1.20	1.2
Dec	1.00	0.64					1.00		0.60	0.60	0.40	0.60	0.60	0.6
							Σ J—>D		46.10	39.20	41.30	40.20	41.90	40.2
							Σ M—>O		41.90	35.20	38.40	36.20	37.90	36.2

Note: ∑ J----->D = January through December
∑ M----->O = March through October

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[1]Kc's from Consumptive Use Model

[2]From meeting of 10/11/95

[3]Kc calculated as Kp/PET from Table 5, Bulletin 113-3. PET is given at top of Table 5.

[4]Column 4,5, and 6 from Table J-3, Bulletin 113-4: Kc for clean tilled with bud out to leaf fall dates.

[5]Table J-3, Bulletin 113-4, deciduous orchard with cover crop.

[6]Average of columns 4,5,6, and 7.

[7]From meeting of 10/11/95

[8]Estimated ETorchard: (column 1 x column 9), note: agrees exactly with DWR/USBR 11/29/79.

[9]Estimated ETorchard: (column 2 x column 9)

[10]Estimated ETorchard: (column 3 x column 9)

[11]Estimated ETorchard: (column 8 x column 9)

[12]Estimated ETorchard: from page 2, DWR/USBR 11/29/79. Note: ET column 12 agrees exactly for 1968-77 yr.

Crop Coefficients (Kc) and ET for VINEYARD
in Sacramento/San Joaquin Delta

	1[1]	2[2]	3[3]	4	5	6[4]	7[5]	8[6]	9[7]	10[8]	11[9]	12[10]
	<——————Kc's——————>											
		<——B113-4, Table J-3——>										
	consump								Est.	Est.	Est.	Est.
Month	use model	DOP 1995	3/1-11/8	3/15-11/8	4/15-11/8	Avg.	B113-3	ETo	ETv	ETv	ETv	ETv
Jan	1.00	0.13						0.70				
Feb	1.00	0.13						1.50				
Mar	0.57	0.14	0.22	0.16		0.13		3.00	1.70	0.40	0.40	
Apr	0.33	0.36	0.61	0.44	0.14	0.40	0.16	4.50	1.50	1.60	1.80	0.7
May	0.60	0.61	0.80	0.73	0.38	0.64	0.58	6.00	3.60	3.70	3.80	3.5
Jun	0.71	0.78	0.85	0.84	0.71	0.80	0.77	6.90	4.90	5.40	5.50	5.3
Jul	0.82	0.84	0.84	0.85	0.83	0.84	0.85	7.80	6.40	6.60	6.60	6.6
Aug	0.83	0.79	0.67	0.77	0.85	0.76	0.83	6.40	5.30	5.10	4.90	5.3
Sep	0.78	0.58	0.34	0.51	0.80	0.55	0.71	4.60	3.60	2.70	2.50	3.3
Oct	0.41	0.37	0.26	0.26	0.59	0.37	0.40	2.70	1.10	1.00	1.00	1.1
Nov	0.79	0.24						1.40				
Dec	1.00	0.14						0.60				
					TOTAL			46.10	28.10	26.50	26.50	25.8

Note: Terry Pritchard, UC Cooperative Extension, San Joaquin County, says wine grapes bud out in April, not March. Therefore, ET's in column 12 would be more in agreement with his statement.

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[1]Kc from Consumptive Use Model: (ETcrop/ETo), handout table, meeting of 10/11/95

[2]Kc's based on DWR Bulletin 113-4, revised to concur with S.J. Co. Farm Advisor comments described in G. Sato memo of 10/94 to Tariq Kadir.

[3]Columns 3,4, and 5 from Table J-3, Bulletin 113-4 for early, mid, and late leaf out respectively.

[4]Kc vineyard; average of columns 3,4, and 5.

[5]Kc calculated as Kp/PET from Table 5, Bulletin 113-3. PET is given at top of Table 5.

[6]"new variable Delta ETo" average 1922 to 1992 from tabulation dated 10/11/95.

[7]Estimated ETv: (column 8 x column 1)

[8]Estimated ETv: (column 8 x column 2)

[9]Estimated ETv: (column 8 x column 6)

[10]Estimated ETv: (column 8 x column 7)

The next four pages of tables (Table F through Table H) illustrate the analysis done to derive the composite estimate of ET values for field crops. Milo, corn, and dry bean crops were selected for this analysis.

The first table (Table F) lists ET values for field crops used in the past. The second table (Table G) shows the pertinent Kc values for this analysis. The third and fourth tables (Tables H and I) illustrate the determination of the composite ET values of the three field crops mentioned above, based on individual crop ET values from two different sources.

TABLE F
Estimated ET for Miscellaneous Field Crops
Summary of Various Estimates

Month	11/3/1976[1] Table B-8	DWR/[2] USBR	DWR 113-4[3] D.O.P	M. Roos[4] C.U. Model
Jan	0.7	0.7	0.1	0.7
Feb	1.5	1.5	0.2	1.5
Mar	2.3	1.9	0.5	1.7
Apr	1.7	1.8	0.8	1.6
May	2.5	2.6	1.6	2.6
Jun	5.8	5.8	3.9	5.5
Jul	6.9	6.9	7.3	7.3
Aug	4.1	4.1	6.2	4.9
Sep	1.8	1.8	3.0	2.2
Oct	1.1	1.1	0.9	1.1
Nov	1.4	1.1	0.3	1.1
Dec	0.6	0.6	0.1	0.6
Mar - Oct	26.2	26.0	24.2	26.9
Jan - Dec	30.4	29.9	24.9	30.8

Note: Estimates based on ⅓ milo, ⅓ corn, and ⅓ dry bean crop mix, except C.U. Model column, which is not specified. I cannot find crop mix in DWR Bulletin 113-4, Table J-3 to match the Kc's listed in column: "DWR Bulletin 113-4, D.O.P."

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[1]Estimate ETfield based upon Table B-8 memo: Central Valley Hydrology, November 3 , 1976.

[2]Estimate ETfield based upon monthly crop ET's agreed upon by DWR and USBR, tabulation 11/23/79

[3]Estimate ETfield from DWR Bulletin 113-4 and revised to concur with comments in G. Sato's memo of 10/96

[4]Estimate ETfield calculated by D.O.P. from data in M. Roos, C.U. model and listed in handout from 10/11/95 meeting.

C-054299

Crop Coefficient (Kc) and Estimated Crop ET for Misc. Field Crop
Sacramento/San Joaquin Delta

	1	2	3	4	5
Month	Kc[1] CU Model	Kc[2] 10/11/95	Est.[3] ETo	ET_f[4] C.U. Model	ET_f[5] 10/11/95
Jan	1.00	0.17	0.70	0.70	0.10
Feb	1.00	0.16	1.50	1.50	0.20
Mar	0.57	0.16	3.00	1.70	0.50
Apr	0.36	0.18	4.50	1.60	0.80
May	0.43	0.27	6.00	2.60	1.60
Jun	0.80	0.56	6.90	5.50	3.90
Jul	0.94	0.93	7.80	7.30	7.30
Aug	0.77	0.97	6.40	4.90	6.20
Sep	0.48	0.65	4.60	2.20	3.00
Oct	0.41	0.35	2.70	1.10	0.90
Nov	0.79	0.24	1.40	1.10	0.30
Dec	1.00	0.22	0.60	0.60	0.10
Mar - Oct			41.90	26.90	24.20
Jan - Dec			46.10	30.80	24.90

[1]Kc's for field crop category calculate by ETcrop ÷ PET, from CU model.

[2]Kc's from Bulletin 113-4, revised per G. Sato 10/94, memo.

[3] "New" estimate of ETgrass for Delta from 10/11/95 tabulation.

[4]Estimate ET_{field} crops (column 1 x column 3), CU model.

[5]Estimate ET_{field} crops (column 2 x column 3), most recent estimate from 10/11/95 meeting.

Estimated Misc. Field Crop ET and Kc's for Sacramento/San Joaquin Delta

	1	2	3	4	5	6	7	8
		<——	Crop ET inches	——>				
Month	PET[1]	Milo[2]	Corn[2]	Beans[2]	Average[3]	Calc. Kc[4]	ETo[5]	ET_f[6]
Jan	0.7	0.7	0.7	0.7	0.7	1.00	0.7	0.7
Feb	1.5	1.5	1.5	1.5	1.5	1.00	1.5	1.5
Mar	2.7	2.1	2.1	2.1	2.1	0.78	3.0	2.3
Apr	4.1	1.5	1.5	1.5	1.5	0.37	4.5	1.7
May	5.5	2.3	2.7	1.9	2.3	0.42	6.0	2.5
Jun	6.4	5.5	5.3	5.3	5.4	0.84	6.9	5.8
Jul	7.6	7.2	6.8	6.1	6.7	0.88	7.8	6.9
Aug	6.6	4.4	5.3	2.8	4.2	0.64	6.4	4.1
Sep	4.6	1.7	2.5	1.2	1.8	0.39	4.6	1.8
Oct	2.8	1.0	1.2	1.0	1.1	0.39	2.7	1.1
Nov	1.4	1.4	1.4	1.4	1.4	1.00	1.4	1.4
Dec	0.6	0.6	0.6	0.6	0.6	1.00	0.6	0.6
Mar - Oct					25.1			26.2
Jan - Dec	44.5	29.9	31.6	26.1	29.3		46.1	30.4

Note: These calculations based on Table B-8, memo 11/3/76, Central Valley Hydrology, except columns 7 and 8.

[1]Average year PET = ETgrass from Table B-8, Central Valley Hydrology, memo 11/3/76

[2]From Table B-8, memo 11/3/76: ET weighted for ⅓ early, ⅓ mid, and ⅓ late season planting.

[3]Average ET for milo, corn, beans = average of columns 2, 3, and 4.

[4]Calculated Kc for misc field crops = column 5 ÷ column 1.

[5]ETo 10/11/95 meeting tabulation New Variable ETo Delta.

[6]Estimated ET_f grouping (milo, corn, beans) using Kc's from column 6 and ETo from Column 7.

Estimated Misc. Field Crop ET and Kc's for Sacramento/San Joaquin Delta

	1	2	3	4	5	6	7	8
		<——	Crop ET inches	——>				
Month	PET[1]	Sorghum[2]	Corn[2]	Beans[2]	Average[3]	Calc. Kc[4]	ETo[5]	ET,[6]
Jan	0.7	0.7	0.7	0.7	0.7	1.00	0.7	0.7
Feb	1.5	1.5	1.5	1.5	1.5	1.00	1.5	1.5
Mar	2.7	1.7	1.7	1.7	1.7	0.63	3.0	1.9
Apr	4.1	1.6	1.6	1.5	1.6	0.39	4.5	1.8
May	5.5	2.6	2.6	1.9	2.4	0.44	6.0	2.6
Jun	6.4	5.5	5.5	5.3	5.4	0.84	6.9	5.8
Jul	7.6	7.3	7.3	5.8	6.8	0.89	7.8	6.9
Aug	6.6	4.9	4.9	2.8	4.2	0.64	6.4	4.1
Sep	4.8	2.2	2.2	1.2	1.9	0.40	4.6	1.8
Oct	2.8	1.1	1.1	1.0	1.1	0.39	2.7	1.1
Nov	1.4	1.1	1.1	1.1	1.1	0.79	1.4	1.1
Dec	0.6	0.6	0.6	0.6	0.6	1.00	0.6	0.6
Mar - Oct					25.1			26.0
Jan - Dec	44.7	30.8	30.8	25.1	29.0		46.1	29.9

Note: Based on ET's agreed to by DWR/USBR 11/29/79. ET's for sorghum, corn, and dry beans as listed in tabulation DWR/USBR 11/29/79 are averages for each crop for early, mid, and late planting/harvest. Crop mix is ⅓ each crop.

The above evaluation of Kc coefficients and ETo values, relative to field crops, generated the following observations and comments:

1. The most recent estimation of Kc's and crop ET for miscellaneous field crops, as calculated by Hydrology Development Unit, DOP, seem low as compared to three other estimates.

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[1]ETpasture from DWR/USBR agreement 11/29/76, "Notes" on Nov. 26 meeting between DWR/USBR.

[2]ET sorghum, corn, and dry beans. ETcorn = ETsorghum. From Tabulation per DWR/USBR agreement.

[3]Average of columns 2, 3, and 4.

[4]Calculated Kc for misc Field Crops, column 5 ÷ column 1.

[5]Delta ETo from DOP tabulation 10/11/95.

[6]Estimated ET for misc Field Crops, column 6 x column 7.

From memo 11/03/76	26.2 inches
From memo 11/29/79	26.0 inches
From CU model	26.9 inches
Most recent, 10/11/95	24.2 inches

Note: Most recent is about eight percent lower than average of other three.

2. Recommended use Kc's from DWR/USBR 11/29/79, as they agree well with memo, 11/3/76, and Consumptive Use Model. These are listed in Table J.

The recommended monthly Kc's and the average crop ET's which are applicable to the Delta are summarized in the following tables (Table J and Table K). Table K contains the recommended Kc values for estimating growing season ET for the crop categories contained in the table as well as water surface and riparian vegetation. Table K contains corresponding (growing season and non-growing season) ET values by the same crop categories.

C-054303

Recommended Monthly Kc's for Estimating
Growing Season ET of Various Crops
In Sacramento/San Joaquin Delta

Month	Pasture[1] and Alfalfa	Misc[2] Field	Field[3] Corn	Sugar[4] Beets	Sugar[5] Beets	Irrig[6] Grain	Rice[7]	Misc[8] Truck	Tomato Hand[9] pick	Tomato Machine[10] pick	Deciduous[11] Orchard	Vine-[12] yard	Water[13] surface, Riparian
Jan	1.00			1.20		1.00							1.43
Feb	1.00			1.20		1.00							1.27
Mar	1.00	0.63	0.63	1.20	0.63	1.00		0.70	0.78	0.59	0.63		1.26
Apr	1.00	0.39	0.39	1.15	0.32	1.12	0.51	0.37	0.37	0.32	0.66	0.37	1.24
May	1.00	0.44	0.47	0.65	0.58	0.91	1.16	0.27	0.60	0.58	0.89	0.65	1.25
Jun	1.00	0.84	0.86		0.94	0.34	1.28	0.56	0.95	1.00	0.92	0.77	1.23
Jul	1.00	0.89	0.96		1.04		1.28	0.97	1.04	1.09	0.92	0.84	1.18
Aug	1.00	0.64	0.74	0.40	1.00		1.28	0.94	0.97	0.83	0.92	0.80	1.21
Sep	1.00	0.40	0.46	0.30	1.00		1.17	0.79	0.74	0.35	0.92	0.75	1.23
Oct	1.00	0.40	0.40	1.00	0.79		0.69	0.57	0.57		0.89	0.39	1.32
Nov	1.00			1.20		0.79							1.21
Dec	1.00			1.20		1.00							1.56

Note: Table lists monthly Kc's for growing season. For non-growing season months, ET = precipitation, not to exceed PET (ETo) and where there is stored soil moisture and PET does exceed rainfall, use up to 0.75 inches soil moisture per month, for a maximum of three months: Total ET not to exceed PET. See DWR Bulletin 113-3, page 27.

It is presumed that in an "average year", the combination of precipitation and stored soil moisture adequately meets the imposed evapotranspiration during the non-growing season. Therefore, it is also presumed that the respective Kc values for all crops for that same year are 1.0.

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[1] Alfalfa ET = Pasture ET per agreement DWR/USBR 11/29/79 and assume Pasture ET = Calculated ETo.

[2] Assume ⅓ Sorghum, ⅓ Field Corn, and ⅓ Dry beans. Based on average year crop ET's agreed to by DWR/USBR 11/29/79. Weighted for early, mid, and late planting and harvest.

[3] Kc corn based upon average year ET's per DWR/USBR agreement 11/29/79 and weighted for early, mid, and late season planting and harvest.

[4] Sugar Beets are over wintered. Plant mid August harvest May 1 to May 15

[5] Sugar Beets Annual Crop. Plant March 1-15, Harvest October 15-31.

[6] Plant Nov. 1, irrigate to germinate, harvest mid June. Kc's calculated from ETgrain/ETpasture per DWR/USBR.

[7] Based on ET data, Table 5, DWR Bulletin 113-3.

[8] Potatoes ½, Asparagus ½. ET asparagus per DWR/USBR agreement and ET potato from Table 5, B 113-3.

[9] Hand picked tomato based on DWR/USBR agreement, ET adjusted for longer growing season, use prior to 1965.

[10] Machine harvest tomato ET per DWR/USBR agreement. Use for 1965 and later.

[11] Based on DWR/USBR agreement 11/29/79.

[12] Wine grapes with growing season April through October, per Terry Pritchard UC Ag. Ext., San Joaquin Co. Based on ET's per DWR/USBR agreement 11/29/79.

[13] Evaporation from Water Surfaces and Riparian Vegetation per values agreed to by DWR/USBR 11/29/79.

Estimated "Average Year" Evapotranspiration
for several crops[1]
Sacramento/San Joaquin Delta

ET in INCHES

Month	Pasture and Alfalfa	Misc Field	Field Corn	Sugar[2] Beets	Sugar[3] Beet	Irrig Grain	Rice	Misc Truck	Tomato Hand pick	Tomato Machine pick	Deciduous Orchard	Vine-yard	Water surface Riparian
Jan	0.7	0.7	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	1
Feb	1.5	1.5	1.5	1.8	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1
Mar	3.0	1.9	1.9	3.6	1.9	3.0	2.3	2.1	2.3	1.8	1.9	2.3	3
Apr	4.5	1.8	1.8	5.2	1.4	5.0	2.3	1.7	1.7	1.4	3.0	1.7	5
May	6.0	2.6	2.8	3.9	3.5	5.5	7.0	1.6	3.6	3.5	5.3	3.9	7
Jun	6.9	5.8	5.9	1.0	6.5	2.3	8.8	3.9	6.6	6.9	6.3	5.3	8
Jul	7.8	6.9	7.5	1.0	8.1	1.0	10.0	7.6	8.1	8.5	7.2	6.6	9
Aug	6.4	4.1	4.8	2.6	6.4	1.0	8.2	6.0	6.2	5.3	5.9	5.1	7
Sep	4.6	1.8	2.1	1.4	4.6	1.0	5.4	3.6	3.4	1.6	4.2	3.4	5
Oct	2.7	1.1	1.1	2.7	2.1	1.0	1.9	1.5	1.5	1.0	2.4	1.1	3
Nov	1.4	1.1	1.1	1.7	1.1	1.1	1.4	1.2	1.4	1.1	1.2	1.4	1
Dec	0.6	0.6	0.6	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0
Growing Season[4]	46.1	26.0	27.9	24.4	34.5	19.7	43.6	28.0	33.4	29.0	36.2	27.1	57
January-December	46.1	29.9	31.8	26.4	38.4	23.7	50.1	32.0	37.6	33.9	40.2	33.6	57

Note: ET estimates are for an "average year" where ETo = 46.1 inches with monthly distribution as tabulated per memo 10/11/95.

For non-growing season months, ET = precipitation, not to exceed PET (ETo); and where there is stored soil moisture and PET does exceed rainfall, use up to 0.75 inches soil moisture per month, for a maximum of three months. Total ET not to exceed PET. See DWR Bulletin 113-3, page 27.

The following, Table L, Comparison of 3 Estimates of Total Growing Season ET for Several Delta Crops, compares the ET values from: (1) D.O.P. Consumptive/Use

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[1]Crop ET per DWR/USBR agreement 11/29/79, adjusted from "average year" of period 1968 to 1977 (ETo = 44.7") to average of 1922 to 1992 (ETo = 46.1").

Growing season ET's calculated as Kc's per tabulation Recommended Monthly Kc's for Estimation Growing Season ET of Various Crops in Sacramento/San Joaquin Delta, Norman MacGillivray, 2/10/96, multiplied by ETo as tabulated by D.O.P., 10/11/95.

[2]Sugar Beets are over wintered. Plant mid August, harvest May 1-15

[3]Sugar Beets; Annual Crop. Plant March 1-15, harvest October 15-31.

[4]Assumed growing seasons: Jan - Dec: Alfalfa, Pasture, and Water Surface.
Mar - Sep: Tomatoes (Machine Harvest)
Mar - Oct: Misc. Field, Field Corn, Misc. Truck, Tomatoes (Hand-Pick), and Deciduous Orchard.
Apr - Oct: Rice and Vineyard.
Nov - Jun: Small Grain.

Model, (2) D.O.P. recalculated ET values based on the current ETo estimate of 46.1 inches (refer to report by MacGillivray/Sato dated October 1994) and Kc's from Table J-3, DWR Bulletin 113-4, and (3) the latest estimates derived, dated 2/12/96.

The D.O.P. consumptive use model assumes that sugar beets are grown during the normal cropping season, March through October. George Sato recalls that in the late 1970's and early 1980's that was the prevalent cultural practice. There was some question if the current growing season for sugar beets is about November 1 through June (or earlier), as weather and/or processor permits harvesting. According to Terry Pritchard, San Joaquin County Farm Advisor, growing sugar beets as a summer crop is still the predominate practice in the Delta. It should be noted, however, that some Delta sugar beets are overwintered. The table shows values for all crops reasonably compare.

TABLE L

Comparison of 3 Estimates of Total Growing Season ET for Several Delta Crops Estimated ET in inches

Crop	ET[1] CU Model	"New" [2] Estimate	Estimate of [3] 2/12/96
Pasture	44.7	46.1	46.1
Alfalfa	44.7	46.1	46.1
Misc. Field	26.9	24.2	26.0
Sugar Beets[4]	33.8	40.0	34.5
Sugar Beets[5]			24.4
Grain	18.4	19.9	19.7
Rice	42.5	44.0	43.6
Misc. Truck	29.0	28.7	28.0
Tomato (machine)	29.0	28.7	29.0
Deciduous Orchard	35.2	38.5	36.2
Vineyard	26.4	26.0	27.1
Water Surface/Riparian	55.4	55.3	57.1

[1] Values used by Consumptive Use Model per memo 10/11/95.

[2] Calculated ET's by D.O.P. using newest available data. ETo = 46.1 and Kc's from Table J-3, B113-4.

[3] Current estimate, based on DWR/USBR and B113-3.

[4] Annual Crop Sugar Beets.

[5] Over wintered Sugar Beets.

In conclusion, it should be recognized that the recommended Kc factors and ET values for the "average year" (Tables J and K) are the result of a meticulous effort. The basis for these recommended values is documented herein for future reference. The recommended values are in general agreement with previously agreed upon values between DWR and USBR. These values are traceable to actual field data contained in DWR Bulletin 113-3.

However, these recommended values may be subject to revision under certain circumstances. Some examples of contributing circumstances are:

1) Changes in crop planting and harvesting dates (e.g. sugar beets).

2) Changes in mode of harvesting, (e.g. hand picked vs. machine harvested tomatoes).

3) Changes in weed control practices during the non-growing season.

4) Changes in growing season imposed by varietal changes.

5) Changes in composition of crop groupings (e.g. field crop category including corn, safflower, dry beans, etc.).

6) Other changes in cultural practices, such as implementation of end of growing season water stress in vineyards for quality control.

The above suggests that in finalizing the water use in the Delta for the historical period (i.e., 1923 to the present), answers to the following questions may be required if the initial analysis shows that further refinements are required.

1) When did the transition from hand picked to machine harvested tomatoes occur?

2) When did the shift of sugar beets from normal season to overwintered planting occur?

3) Was weed control on crop lands during the non- growing season historically maintained at the present level?

4) Has the composite crop mix for the identified crop groupings (e.g. truck, field, etc.) changed substantially during the historical period?

5) Were some seasons so dry that to use the "Average Year" Kc values for non-growing season appears inappropriate?

Appendix A
References

Delta historical evapotranspiration meeting (DWR, Planning, Modeling Support Branch), January 25, 1995: Handouts including graphs depicting various crop Kc coefficients.

DWR Bulletin 113-3, April 1975.

DWR Bulletin 113-4, April 1986.

DWR Bulletin 168, October 1978.

Estimation of Monthly Crop Evapotranspiration for Central Valley Hydrology Study, DWR Memo Report, November 3, 1976.

Evaluation of ET_{grass} (ETo) in the Delta Area, DWR Office Report, October 1994.

Joint DWR and WPRS Delta Channel Depletion Analysis, April 1, 1981.

Meeting with Mr. Franz Kegel and Mr. Terry Prichard, Farm Advisors, UC Cooperative Extension, San Joaquin County, September 26, 1994.

New Variable Delta ETo (Table), DWR October 11, 1995.

DWR Revised Estimate of Adjusted Water Quantities, Water Bank Fallowing Program in the Delta, July 24, 1991.

Revised Lower San Joaquin Valley Crop ETo, May 19, 1976.

Rich Cocke's compilation of notes from the November 28, 1979 meeting between DWR and WPRS staffs, (leading to Joint DWR and WPRS Delta Channel Depletion Analysis).

APPENDIX B
DELTA FIELD OBSERVATIONS
BY GEORGE SATO AND NORMAN MACGILLIVRAY
ON NOVEMBER 16 & 29, 1995

Photo No.	Description
1A & 1B	A field immediately north of the town on Freeport and east of Highway 160. The observed surface shows six inches of the soil is totally dry. Apparently a grain crop is being planted with the anticipation of rain for germination.
1C	In Yolo County and a few miles north of the town of Clarksburg, a field southwest of the intersection of Willow Road and Will Avenue. The field is under preparation for planting. Hard dry clods are being pulverized with the equipment shown by the photo. Soil is totally dry to an observed depth of about ten inches.
2 & 3 & 4	On Grand Island due west on Orchard Lane. According to Jim Shoeman, the fields shown on these two photos are anticipated to be planted with crops other than wheat. An adjacent field was planted with wheat fifteen days prior. Jim mentioned that soil moisture is in the subsoil due to high river water level experienced this year, but the surface soil moisture is inadequate for uniform germination. Photo 4 is a close-up to show surface soil moisture conditions indicating the occurrence of sparse wheat germination in places.
5 & 6	Planted wheat fields at the same vicinity as described above. Photo 5 shows a field located northwest of Orchard Lane, and Photo 6 shows a field in the opposite direction or facing southeast from the same spot. The planted wheat fields are checked to accommodate drainage of excess rainfall water.
7	A corn field located about one-half to one mile west of the Sacramento River and off Leary Road on Grand Island under harvest. The photo depicts the maturity of corn fields, dryness of soil surface (which has the same effect as mulching in subduing subsoil moisture evaporation), and lack of weeds that can contribute to soil moisture loss by evapotranspiration.

Photos 8 through 12 taken on Staten Island showing various field conditions and practices:

8	An untilled field showing some weed growth contributing to ET process. Water seepage is from the adjacent field flooded for wildlife.

9	Field flooded for wildlife.
10 & 11	Flooded fields being occupied by migrating waterfowl.
12	Dry condition of cleanly tilled field. (Normally dry to the tilled depth.)
13 & 14	A pear orchard occupying upper end of Andrus Island and next to Georgiana Slough. The photo depicts the typical foliage condition of pear orchards (as of this date).
15	A vineyard occupying mid-point between Walnut Grove and Isleton on Andrus Island. Photo showing the foliage conditions of two separate vineyard plantings. The planting in the foreground shows a foliage condition that suggests that the ET process has largely terminated. On the other hand, the planting in the background suggests a continuation of maximum ET process.
16 & 17	Photos showing the moisture condition of a field located southwest of Isleton being tilled. The field observed from a distance suggested (by color) a surprising level of soil surface moisture.
18	On Andrus Island north of Highway 12 and viewing westerly from Terminous Road. A harvested corn field with dry soil surface and essentially free of weeds.
19	Same site as Photo 18 but viewing in northwest direction. The field shown in the foreground is the same field described above. The field in the background is unharvested corn field infested with Johnson Grass which indicates ample subsoil moisture.
20	On Bouldin Island, about one to one and one-half miles east of Mokelumne River, and viewing southwesterly direction from Highway 12. The photos show self-germinated small grain crop where surface soil moisture is adequate for germination. This is the only field observed where germination of small grains is relatively uniform.
21	Near central area of Terminous Tract and viewing northerly from Highway 12. Harvested corn field showing some infestation of Johnson Grass. This appears to be a typical occurrence on Terminous Tract. Again, surface soil is dry, but apparently not the subsoil.
22	Also in central area of Terminous Tract but further east of the above site. Vineyard inter-cropped with "grain-like" crop. This is the only area in which this practice was observed.

23 Foliage condition of the vineyard described above indicates a continuation of evapotranspiration, but to a limited extent.

24 A field in the opposite direction from the one described above (Photo 22) but viewing eastward.

25 An asparagus field near Highway 4 (about one mile north of the highway and one and one-half miles east of Whiskey Slough) on Lower Roberts Island. The prevalent foliage conditions of other observed asparagus fields can be described as being the mix of two distinct conditions reflected by the photo.

As can be anticipated, cultural practices, soil moisture, weed growth, etc. can vary substantially among individual farms. However, the following generalizations can be made from our observations:

- Post-harvest tilling shortly after harvest (particularly after small grain, safflower and tomatoes) appears to be a standard practice. Annual crops which are most likely to remain untilled after harvest are late-harvested corn crops.

- Weed problems after harvest appear to be well under control. An exception to this may be on some farms heavily infested with Johnson Grass.

- The observed foliage conditions suggest that about one-third to one-half of the perennial crop acreage (asparagus, vineyard, pear, etc.) may continue to ET through the month of November, if the growing season is not interrupted by frost.

- The soil moisture levels of a clean tilled grain field above or near sea level can become very dry to a depth exceeding one foot. The surface soils of a similar field below sea level, on the other hand, are generally moist; and germination of small grains planted in early fall may be possible, under certain circumstances, without additional irrigation and/or rainfall.

- Soil moisture losses by surface evaporation from a field, clean tilled early in the summer season, is largely limited to the tilled depth.